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National Eutrophication Survey, Las Vegas, Nev

Prepared for

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REPORT

ON

CASCADE RESERVOIR

VALLEY COUNTY

IDAHO

EPA REGION X

WORKING PAPER No. 777

WITH THE COOPERATION OF THE

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AND THE

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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VALLEY COUNTY, IDAHO

EPA REGION X

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 777

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U.S. ENVIRONMENTAL PROTECTION AGENCY

July 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Idaho Department of Health and Welfare for professional involvement, to the Idaho National Guard for conducting the tributary sampling phase of the Survey, and to those Idaho wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the State of Idaho Department of Health and Welfare, Division of Environment, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

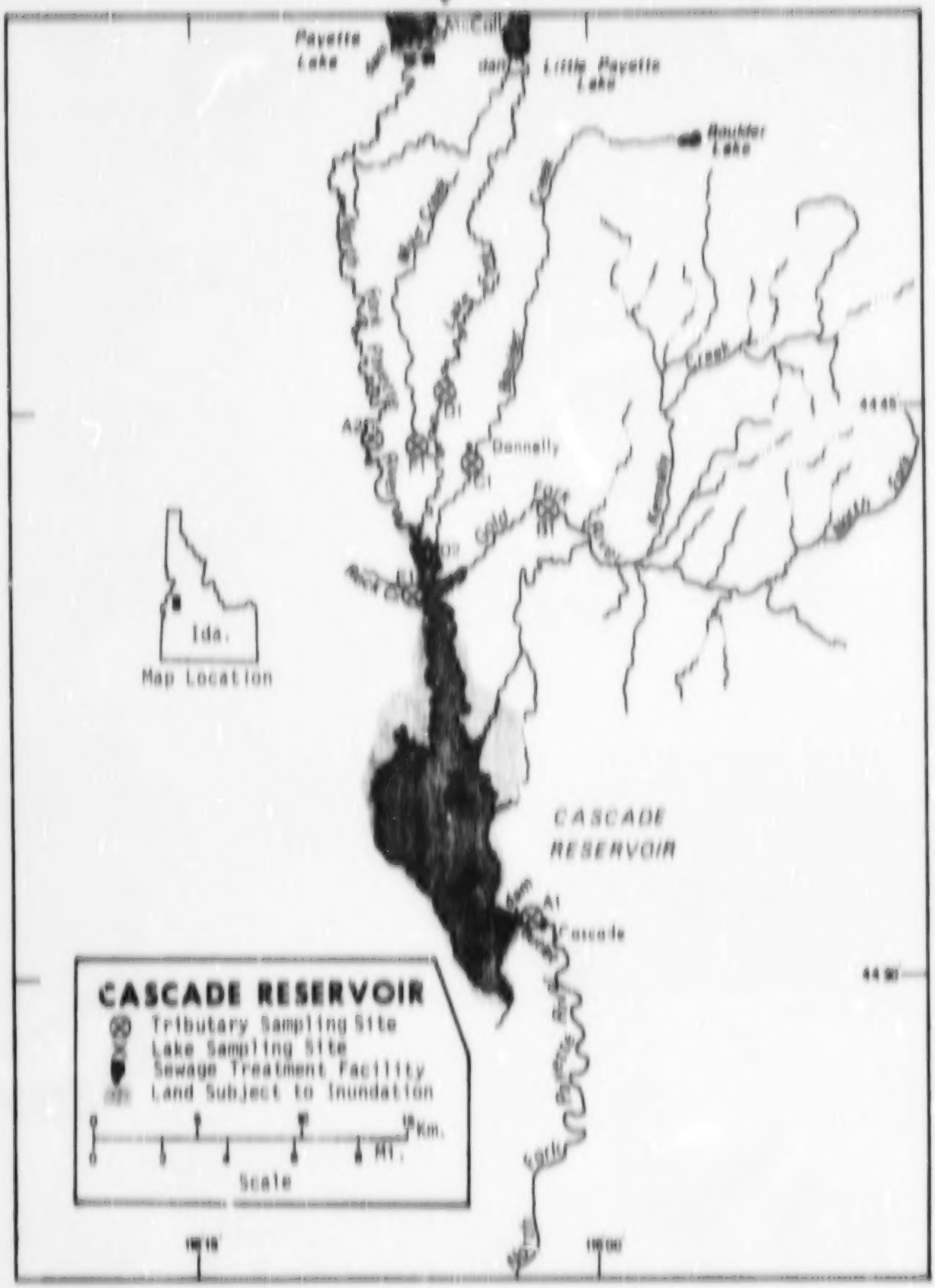
Major General James S. Brooks, Adjutant General of Idaho, and Project Officer Major Vestal L. Baker, who directed the volunteer efforts of the Idaho National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF IDAHO

LAKE NAME	COUNTY
American Falls Reservoir	Bannock, Bingham, Power
Cascade Reservoir	Valley
Coeur d'Alene Lake	Benewah, Kootenai
Dworshak Reservoir	Clearwater
Hauser Lake	Kootenai
Hayden Lake	Kootenai
Island Park Reservoir	Fremont
Lake Lowell (Deer Flat Reservoir)	Canyon
Magic Reservoir	Blaine, Camas
Palisades Reservoir	Bonneville (Lincoln in WY)
Payette Lake	Valley
Lower Twin Lake	Kootenai
Upper Twin Lake	Kootenai


Payette Lake
Little Payette Lake
Boulder Lake
Donnelly
Ida.
Map Location
CASCADE RESERVOIR
Cascade
CASCADE RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Land Subject to Inundation
Km.
Mi.
Scale

REPORT ON CASCADE RESERVOIR, IDAHO

STORET NO. 1602

I. CONCLUSIONS

A. Trophic Condition:*

On the basis of Survey data, Cascade Reservoir is considered eutrophic, i.e., nutrient rich and highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake.

Chlorophyll a levels in the lake ranged from 4.1 µg/l to 14.3 µg/l with a mean of 8.1 µg/l. Potential for primary productivity as measured by algal assay control yields was high. Of the 13 Idaho lakes sampled in 1975, 4 had greater median total phosphorus levels, 6 had greater median inorganic nitrogen values, and 5 had greater median orthophosphorus levels than Cascade Reservoir.

Survey limnologists reported moderate concentrations of algae in the lake during August and September sampling, and severe oxygen depression with hydrogen sulfide production was reported during September at Station 01. Other studies (Idaho Department of Water Resources et al. 1975; Idaho Department of Health and Welfare, 1975 and 1976; Bureau of Reclamation, 1975) indicate

*See Appendix E.

that seepage of shoreline recreational homes, and excessive algal growths, low oxygen levels in deeper waters, minor fish kills, and shoreline macrophyte growths due to nutrient contamination from agricultural runoff are problems of increasing significance in Cascade Reservoir.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Cascade Reservoir was limited by available phosphorus during both spring and fall sampling (06/04/75, 09/16/75). The lake data suggest primary productivity was limited by available nitrogen during all three sampling rounds.

C. Nutrient Controllability:

1. Point Sources -

Point sources were calculated to have contributed 3.8% of the total phosphorus loading to Cascade Reservoir during the sampling year. The city of McCall, discharging into the North Fork Payette River, contributed this entire load. Wastes from a fish hatchery on the North Fork Payette River, and raw domestic discharges from the community of Donnelly also impact Cascade Reservoir; however, annual nutrient contributions from these sources are not known.

The annual phosphorus loading of 0.38 g $P/m^2/yr$ is less than Vollenweider's "eutrophic" level but greater than his

proposed "oligotrophic" loading for a lake with such volume and retention time. However, the lake is obviously eutrophic, and removal of inputs from point and nonpoint sources would probably be necessary to effect lake water quality improvement. A waste treatment plant has recently been completed at Donnelly and should substantially improve water quality flowing from Boulder Creek into Cascade Reservoir. The Bureau of Reclamation (1975) has also recommended monitoring those lake areas affected by rapid development of recreational homesites, and suggested a switch from use of individual septic tanks to back-set sewage disposal lagoons to reduce the impact of the rapidly expanding domestic development around the lake.

2. Nonpoint sources -

Nonpoint sources, including precipitation, contributed 96.2% of the total phosphorus loading to Cascade Reservoir. The Gold Fork River contributed 25.0% of the total load, the North Fork Payette River, 21.3%, and Lake Fork Creek contributed 15.1%. Ungaged drainage areas were estimated to have contributed 24.8% of the total phosphorus load.

Phosphorus export rates of all four tributaries to Cascade Reservoir were higher than would be expected from nonpoint

contribution alone (Section IV-D), and excessive algal growths have been reported in most of them (Bureau of Reclamation, 1975). The Bureau has recommended that management practices in the Cascade watershed be modified by reducing grazing during spring high runoff periods and preventing cattle from reaching the lake to help lower nutrient levels and microorganism counts in Cascade Reservoir.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area, mean depth and volume were provided by the U.S. Geological Survey (USGS) (1972), and Martin and Hanson (1966). Maximum depth was estimated on the basis of National Eutrophication Survey (NES) sampling data. Tributary flow data were provided by the Idaho District Office of the USGS. Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 107.24 km^2
2. Mean depth: 8.1 meters
3. Maximum depth: 18.3 meters
4. Volume: 867,390 x 10^6 m^3
5. Mean hydraulic retention time: 339 days

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area (km^2)	Mean flow (m^3/sec)
A-2 North Fork Payette River	440.3	10.19
B-1 Gold Fork River	388.5	5.91
C-1 Boulder Creek	99.7	0.95
D-1 Lake Fork Creek	198.4	3.36
Minor tributaries and immediate drainage -	387.2	6.86
Totals	1514.1	27.26
2. Outlet - A-1 North Fork Payette River	1621.3	29.64

C. Precipitation:

1. Year of sampling: 77.7 cm.
2. Mean annual: 71.6 cm.

III. LAKE WATER QUALITY SUMMARY

Cascade Reservoir was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from five stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 16.8 meters at Station 01, 5.8 meters at Station 02, 8.5 meters at Station 03, 11.9 meters at Station 04, and 8.5 meters at Station 05. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

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B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/04/75	1. Asterionella	5,069
	2. Dinobryon	870
	3. Synedra	605
	4. Centric diatom	151
	5. Melosira	151
	Other genera	417
	Total	7,263
08/01/75	1. Fragilaria	1,206
	2. Aphanizomenon	827
	3. Melosira	276
	4. Chroomonas	138
	5. Aphanothece	103
	Other genera	277
	Total	2,827
09/16/75	1. Aphanizomenon	979
	2. Cryptomonas	367
	3. Fragilaria	245
	4. Chroomonas	82
	5. Melosira	82
	Other genera	40
	Total	1,795

8. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
06/04/75	01	8.1
	02	4.7
	03	6.7
	04	8.1
	05	7.6
08/01/75	01	8.2
	02	5.6
	03	11.2
	04	5.4
	05	4.6
09/16/75	01	6.2
	02	6.3
	03	9.8
	04	14.3
	05	13.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
a. 06/04/75 Stations 01-05			
Control	0.010	0.030	0.9
0.05 P	0.060	0.030	2.5
0.05 P + 1.0 N	0.060	1.030	20.3
1.00 N	0.010	1.030	1.2
b. 09/16/75 Stations 01,04,05			
Control	0.010	0.120	1.2
0.05 P	0.060	0.120	6.4
0.05 P + 1.0 N	0.060	1.120	21.1
1.00 N	0.010	1.120	1.0
Stations 02,03			
Control	0.010	0.085	0.6
0.05 P	0.060	0.085	3.1
0.05 P + 1.0 N	0.060	1.085	21.4
1.00 N	0.010	1.085	0.6

F. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential for primary production in Cascade Reservoir was moderate to high during the spring and fall samplings (06/04/75; 09/16/75). In all assays, the addition of orthophosphorus alone produced a significant increase in yield over that of the control, indicating phosphorus limitation. Note that the addition of nitrogen alone did not result in any substantial increase in yield over that of the control, and that maximum growth increases were achieved with the simultaneous addition of both nutrients.

The mean inorganic nitrogen to orthophosphorus ratios (N/P) in the lake data were less than 8/1 on all sampling occasions, suggesting primary limitation by nitrogen (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Idaho National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of June and July when two samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Idaho District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $kg/km^2/year$, in Gold Fork River at Station B-1, and multiplying the means by the ZZ area in km^2.

Nutrient loads for the McCall wastewater treatment plant were calculated using estimated flows and provided monthly effluent samples.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
McCall	2500	Stabilization pond	0.946*	North Fork Payette River

2. Known industrial - None

*Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 North Fork Payette River	8,620	21.3
B-1 Gold Fork River	10,140	25.0
C-1 Boulder Creek	2,195	5.4
D-1 Lake Fork Creek	6,130	15.1
b. Minor tributaries and immediate drainage (nonpoint load) -	10,065	24.8
c. Known municipal STP's -		
McCall	1,520	3.8
d. Septic tanks* -	<5	<0.1
e. Known industrial - None		
f. Direct precipitation -	1,875	4.6
Totals	40,545	100.0%
2. Output - A-1 North Fork Payette River	25,985	
3. Net annual P accumulation -	14,560	

*Estimate based on 6 lakeshore residences and 1 park.
**Estimated (See NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source		kg N/yr	% of total
a.	Tributaries (nonpoint load) -		
	A-2 North Fork Payette River	171,490	32.9
	B-1 Gold Fork River	83,975	16.1
	C-1 Boulder Creek	20,420	3.9
	D-1 Lake Fork Creek	41,690	8.0
b.	Minor tributaries and immediate drainage (nonpoint load) -	83,635	16.0
c.	Known municipal STP's -		
	McCall	1,600	0.9
d.	Septic tanks* -	90	<0.1
e.	Known industrial - None		
f.	Direct precipitation** -	115,775	22.2
	Totals	521,675	100.0%
2.	Outputs - A-1 North Fork Payette River	829,205	
3.	Net annual N export*** -	307,530	

*Estimate based on 5 lakeshore residences and 1 park.
**Estimated (See NES Working Paper No. 175).
***Export probably due to unknown sources and/or sampling error.

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
North Fork Payette River	20	389
Gold Fork River	26	216
Boulder Creek	22	206
Lake Fork Creek	31	210

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
F-1 Rock Creek	0.034	0.486
F-1 Mud Creek	0.062	0.939

F. Yearly loadings:

In the following table, the existing phosphorus loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic."

Note that Vollenweider's model may not be applicable to water bodies with very short retention times or in which light penetration is severely restricted from high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Cascade Reservoir	0.38
Vollenweider's "eutrophic" loadings	0.58
Vollenweider's "oligotrophic" loading	0.29

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

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APPENDIX C
PHYSICAL AND CHEMICAL DATA

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CASCADE LAKE
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APPENDIX 3

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] [illegible] TO BE LESS
[illegible]

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[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1975

STATE OF IDAHO

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Idaho lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in ug/l. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

[illegible] DATA TO BE USED IN [illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	TOT- [illegible] SIO	[illegible] CHLOR	[illegible] SECC DEPTH	[illegible] [illegible] P
3401	[illegible] FALLS [illegible]	0.171	0.291	441,455	15.374	34.789	0.035
3402	CHICOPEE LAKE	0.132	0.264	415,247	9.597	34.489	0.034
3403	LAKE DEEP [illegible]	0.117	0.242	391,348	18.341	12.459	0.035
3404	[illegible]	0.103	0.220	421,864	2.429	7.480	0.029
3405	[illegible]	0.109	0.275	384,296	11.112	34.459	0.033
3406	[illegible] LAKE	0.113	0.241	341,526	2.787	11.289	0.033
3407	[illegible]	0.134	0.259	778	9.102	12.389	0.032
3408	LAKE LOWELL	0.178	0.276	477,111	25.389	34.345	0.031
3409	[illegible]	0.162	0.238	468,758	7.121	34.769	0.029
3410	[illegible]	0.124	0.240	345,429	2.367	12.356	0.027
3411	[illegible]	0.113	0.250	294,688	4.456	9.389	0.027
3412	[illegible]	0.119	0.256	375,899	2.319	13.467	0.029
3413	[illegible]	0.117	0.234	384,243	4.389	8.259	0.026

[illegible]